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Computerized Aircraft Accident Investigation: Federal Aviation Administration Aviation Safety Inspectors' Perceptions

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COMPUTERIZED
AIRCRAFT ACCIDENT INVESTIGATION:
FEDERAL AVIATION ADMINISTRATION
AVIATION SAFETY INSPECTORS' PERCEPTIONS

by
David S. Ryan

Thesis Submitted to the
School of Graduate Studies and Research
in Partial Fulfillment of the Requirements for Degree of
Master of Aeronautical Science

Embry-Riddle Aeronautical University
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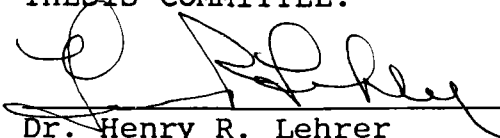
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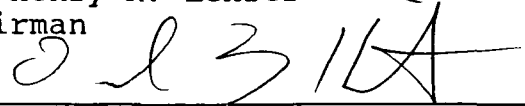
by
David S. Ryan

This thesis was prepared under the direction of the candidate's thesis committee chairman, Dr. Henry R. Lehrer, Department of Aeronautical Science, and has been approved by the members of the thesis committee. It was submitted to the School of Graduate Studies and Research and was accepted in partial fulfillment of the requirements for the degree of Master of Aeronautical Science.

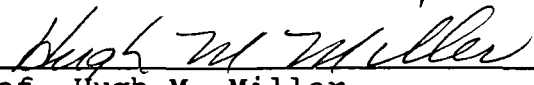
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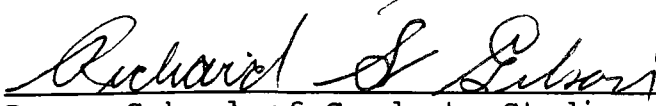
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ABSTRACT

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The purpose of this study was to solicit the perceptions of Federal Aviation Administration (FAA) Aviation Safety Inspectors (ASIs) on the use of a personal computer in the aircraft accident investigation process. A descriptive study survey questionnaire was used to collect the data for the study, which was sent to 150 FAA ASIs. The data collected supported the hypothesis that aircraft accident investigators think the use of a computer will help them with accident report form completion, managing the accident data collected, and in determining the factors contributing to an accident. Furthermore, the data supported the hypothesis that the use of a computer would make the overall process of aircraft accident investigation more efficient.

TABLE OF CONTENTS

| | |
|--|----|
| Introduction | 1 |
| Statement of the Problem | 3 |
| Purpose | 5 |
| Definition of Terms | 5 |
| Statement of the Hypothesis | 6 |
| Method | 7 |
| Subjects | 7 |
| Review of Related Literature | 8 |
| Numeric and Formula Calculation | 8 |
| Checklist Presentation | 10 |
| Information Management | 12 |
| Reporting Form Completion | 15 |
| Expert Systems | 17 |
| Computer End-User Acceptance and Compatibility | 21 |
| Design | 25 |
| Sample Size | 25 |
| Instrument | 27 |
| Procedure | 29 |

| | |
|---|----|
| Data Analysis and Results | 31 |
| Demographic Questions | 32 |
| Cross-Tabulations | 37 |
| Feeling comfortable using a computer versus age . | 37 |
| Feeling comfortable using a computer versus highest | |
| degree earned | 38 |
| Feeling comfortable using a computer versus formal | |
| computer instruction received | 39 |
| Opinion Questions | 40 |
| Conclusions and Recommendations | 55 |
| Conclusions | 55 |
| Recommendations | 59 |
| Suggestions for Further Study | 60 |
| References | 62 |

APPENDICES

| | |
|---|----|
| APPENDIX A: Survey Questionnaire | 66 |
| APPENDIX B: Survey Questionnaire Cover Letter | 72 |
| APPENDIX C: Responses to Opinion Questions 1-10 | 74 |

LIST OF TABLES

Table

| | | |
|-----|---|----|
| 1. | Responses to Survey Question 22 | 32 |
| 2. | Responses to Survey Question 23 | 32 |
| 3. | Responses to Survey Question 24 | 33 |
| 4. | Responses to Survey Question 21 | 34 |
| 5. | Responses to Survey Question 20 | 35 |
| 6. | Responses to Survey Question 11 | 36 |
| 7. | Responses to Survey Question 12 | 36 |
| 8. | Responses to Survey Question 13 | 40 |
| 9. | Responses to Survey Question 14 | 41 |
| 10. | Responses to Survey Question 15 | 42 |
| 11. | Responses to Survey Question 16 | 43 |
| 12. | Responses to Survey Question 17 | 43 |
| 13. | Responses to Survey Question 18 | 44 |
| 14. | Responses to Survey Question 19 | 45 |
| 15. | Responses to Survey Question 25 | 45 |
| 16. | Responses to Survey Question 26 | 46 |
| 17. | Responses to Survey Question 27 | 46 |
| 18. | Responses to Survey Question 1 | 47 |
| 19. | Responses to Survey Question 2 | 48 |
| 20. | Responses to Survey Question 3 | 49 |
| 21. | Responses to Survey Question 4 | 49 |

| | | |
|-----|---|----|
| 22. | Responses to Survey Question 5 | 50 |
| 23. | Responses to Survey Question 6 | 51 |
| 24. | Responses of Survey Question 7 | 52 |
| 25. | Responses to Survey Question 8 | 52 |
| 26. | Responses to Survey Question 9 | 53 |
| 27. | Responses to Survey Question 10 | 54 |

Introduction

Computers have had a tremendous impact on society. Many facets of day to day activity are now handled by some type of computer. The primary idea of using computers is to make it easier to perform complex tasks and furthermore to make the completion of these tasks more efficient. Therefore, with the computer assuming the burden of executing the difficult, redundant, and time-consuming portions of a task, the user can accomplish more of a task in a reduced period of time. The challenge seems to be making the computers as user-friendly as possible and then getting the end-users to incorporate the computers into their daily routine.

Chambers's 20th Century Dictionary (1971 edition) defines a computer as "a machine or apparatus, mechanical, electric or electronic, for carrying out especially complex calculations, dealing with numerical data or with stored items or other information, also used for controlling manufacturing processes, or coordinating parts of a large organization (Sherman, 1985, p. 62)." This definition encompasses a plethora of applications of the computer in today's modern age.

One area in which computers could play a role in time-savings and efficiency is in investigations, or more specifically, aircraft accident investigations. These investigations are very complex in nature and require completeness and the expenditure of many man-hours. The increasing liability issue in the United States supports this case even more by requiring that investigations are performed with increased consistency and accuracy. The aforementioned is overshadowed by the primary fact that the more thoroughly aircraft accident investigations are performed, the more solid a basis can be made to make recommendations to prevent same type accidents from reoccurring.

Statement of the Problem

The increasing need to streamline the aircraft accident investigation sequence is a topic of growing concern among the personnel of the Federal Aviation Administration (FAA) and the National Transportation Safety Board (NTSB). With ongoing government budget reductions, aircraft accident investigators are having to do more work in the same period of time, and for the same or even less money. These investigators are having to delay work on past accidents to respond to present accidents.

The NTSB is the organization responsible for establishing the probable cause of all aircraft accidents (in addition to railroad, marine, pipeline and grade-crossing accidents) and making safety recommendations stemming from respective investigations. With five board members and approximately 340 employees, of which approximately 150 are aircraft accident investigators (Johnson, personal communication, August 26, 1991), it is an on-going challenge for the personnel of the NTSB to investigate and process over 2,000 aircraft accidents (general aviation and air carrier operations) each year.

If the NTSB does not investigate an aircraft accident, it is delegated to the FAA (Hendricks, 1988). As

a result of such delegation, FAA Aviation Safety Inspectors (ASIs) perform numerous aircraft accident investigations. Completing aircraft accident investigations is one of the several duties of an FAA ASI. Therefore, if aircraft accident investigation techniques could possibly be made more efficient, the other responsibilities of ASIs could possibly receive more attention.

Mishaps (accidents) are investigated by parties ranging from untrained persons with limited resources working alone to large investigative teams of experts with nearly unlimited resources (Ferry, 1988). Many mishaps are investigated by persons without any investigative background who have no uniform approach to the task. They usually have minimum resources to meet minimum company or government regulations. The end result of decreased resources seems to create the situation of getting less benefit from of an investigation. Thus, the quality of aircraft accident investigations is another concern in the investigation community.

Edwards (1981) stated that the haphazard nature of accident investigation and analysis provides none of the factors for a base for constructive and positive accident prevention policy. Although much time and effort is given to collecting information, it is not put to constructive use (Edwards, 1981). Accident reporting systems have not been designed as information systems, but have been grown in a

relatively unplanned way. The aircraft accident investigation community needs a method of reporting accidents capable of providing an accurate and effective basis for line management decision making.

The use of a computer is one avenue being considered to make aircraft accident investigation more efficient and consistent (Ryan, 1990). During what part of the investigation will a computer help the most, and to what extent? These are just two questions that were addressed in this study.

Purpose

The purpose of this study was to survey the aircraft accident investigation community to attempt to determine whether the use of a computer would have an impact on the time, effort, and money spent in the investigation of aircraft accidents. The study also attempted to determine the practicality of using a computer in the field. The hardware medium may include such means as a portable laptop computer or pen-type computer.

Definition of Terms

The Oxford English Dictionary (shorter edition) defines a computer as "...one who computes" and it was not until 1973 that the definition of a computer as a machine rather than a person appeared and then only in the Addendum (Sherman, 1985, p. 62). Webster (1988, p. 271) currently defines a computer as "...a programmable electronic device

that can store, retrieve, and process data." Some other definitions pertinent to the subject of this study are listed below.

Expert system. An expert system is a computer program that relies on knowledge and reasoning to perform a difficult task usually undertaken by a human expert (Chignell & Parsaye, 1988).

Laptop computer. A laptop computer is a portable personal computer.

Pen-type computer. A type of computer that uses a pen-type device that replaces a conventional keyboard. The pen is used to touch the screen of the computer, thus picking up voltage that is conducted by a special coating on the screen. The computer measures exactly where and in what order each pen stroke is made and translates the data into digitized characters. This process enables the computer to identify block print, and fill in blocks exhibited on a screen (Buell, 1990; Rebello, 1991).

Statement of the Hypothesis

Research evidence suggests that the use of a computer can be an asset in situations that involve a large number of steps and complex decision making. With automation performing these functions, an aircraft accident investigator can use a computer to make better use of time, energy, and money spent on a task. However, the necessary prerequisite for implementation of such automation is its

acceptance by prospective users. Therefore, it is hypothesized that aircraft accident investigators in the sample think the use of a computer will help them with accident report form completion, managing accident data collected, and in determining factors contributing to an accident. It is further hypothesized, with a computer handling different elements of the aircraft accident investigation process, the ASIs in the sample will think that the process will become more efficient.

Method

Subjects. Prior to the beginning of this study, the researcher obtained a listing of the FAA Aviation Safety Inspectors (ASI) from the FAA employee data base. The ASIs who had completed the Aircraft Accident Investigation Part 2 (AAI-2) training, at the Transportation Safety Institute (TSI), at the Mike Monroney Aeronautical Academy, Oklahoma City, Oklahoma, were separated out. AAI-2 is the official training that FAA Safety Inspectors receive to perform aircraft accident investigations. The obtained listing of AAI-2 graduates totaled 1022 inspectors out of approximately 1836 (as of June 14, 1991) and represented all regions in the FAA. The graduates of the AAI-2 class represented the population (1,022) of this study.

Review of Related Literature

A computer could be used in many facets of an aircraft accident investigation process; research has shown many similar applications. These applications are as follows:

1. Numeric and formula calculation.
2. Checklist presentation.
3. Information management (collection and retrieval).
4. Report form completion.
5. Expert system (problem solving).
6. Human interface and acceptance of automation.

Numeric and Formula Calculation

The first and most basic assistance that a computer can offer to an aircraft accident investigator is the ability to perform mathematical calculations. Many situations are confronted by aircraft accident investigators that require calculations, such as, determining engine RPM and aircraft speed, given the depth and distance between propeller blade strikes in and on the ground (Ellis, 1984; FAA, 1991).

Similar applications of calculating formulas are currently used by law enforcement officers in investigating automobile accidents. Morneau (1984) presented many examples of using computer programs for performing calculations, such as

acceleration rates when speed and time are known or acceleration/deceleration rates when speed lost or gained and time are known. These calculations can be made in both United States measurement and metric measurement. The programs listed in Morneau (1984) are based on formulae and procedures (Rivers, 1981, 1981a). Morneau (1984) also stated that it is apparent that law enforcement officers cannot take the time to investigate in detail every "fender-bender" using the formulae programmed into the computer. However, there are situations which require exceptional investigations - accidents with serious injuries or fatalities where gross negligence is a factor, accidents involving public transportation, including school buses, and accidents involving public interest of a special nature.

Performing these calculations is not limited to an office environment. Murphy (1975) stated by the end of 1974, about 2,500 computer terminals were installed in police cars, and it was estimated that half of the nation's 75,000 police cars were to be equipped with terminals by 1983. These computers access information on criminal records by inputting license plate numbers (Murphy, 1975), but could also be used to access police station computers to perform accident calculations, while still at an accident site.

In the Occupational Safety and Health Management field, computers are now being used in many different applications.

One of these applications, as used by the Occupational Safety and Health Administration (OSHA), determines total case incident rates (Ross, 1984). These are calculations that are based on the number of injuries in a given period of time. The American National Standards Institute (ANSI) uses a similar criterion to calculate their injury-rate determination. Both of these organizations now use computers to carry out injury-incident rate calculations, frequency, and severity rates, thus saving time and effort (Ross, 1984).

Checklist Presentation

Presentation of checklists on a computer could benefit an accident investigator in the field. Computerized checklists are being used more and more in many fields of work. One application of a computerized checklist was to categorize and document the vascular plants of Indiana (Crorello, Keller, & Kartesz, 1983). This computer-based checklist contained all the vascular plants of the state and showed any connections between the species. Thus, one could access a certain species of vascular plant and determine how it relates to another, without spending excessive time searching through books or other types of documentation.

Another form of checklist, more closely related to aviation, is a checklist program developed by the Aviation Safety Analysis System (ASAS), the Facility Inspection Reporting Subsystem for Personal Computers (FIRS/PC). This

checklist is used by FAA security personnel when inspecting FAA facilities, such as, Air Route Air Traffic Control Centers (ARTCC), Airport Traffic Control Towers (ATCT), Joint Surveillance Sites (JSS), etc. (DOT, 1990). The application of the FIRS/PC checklist is not limited to the inspection of physical plants (fences, lighting, security doors, etc.), but is also used to keep track of any sensitive forms or information kept at a facility, e.g., high risk material, telephone monitoring equipment, etc.

A more sophisticated venue of computerized checklists is demonstrated with advanced aircraft technology. Cockpit automation, including cathode-ray tube (CRT) displays, can be programmed to present checklists to the flight-deck crew of modern aircraft (Sexton, 1988). Flight operation checklists for respective modern day aircraft can be called up by flight crews (pre-start checklist, landing checklist, etc.) or automatically presented to the pilot in emergency situations, such as an engine fire or hydraulic system failure. The Airbus A310/A320 aircraft, with the electronic centralized aircraft monitor (ECAM) system, are examples of the application of computerized aircraft cockpit, better known as, cockpit automation. Modern cockpit displays, as in A310/A320 aircraft, have warning displays (WD) and system displays (SD) mounted on the instrument panel. The WD display a "memo" list indicating normal messages and alerts. During an emergency, the WD will display the malfunctioning

system on the SD and a corrective action checklist on the WD for the pilots to follow (Sexton, 1988).

Currently, two projects are underway to develop computerized checklists for aircraft accident investigation. In August 1991, the NTSB installed a newly developed computer program to be used as a checklist to complete the aircraft accident investigation process (Johnson, personal communication, August 26, 1991). This program will be used by personnel in all of the NTSB regional offices and will display checklists on the computer screens depicting the necessary steps that need to be taken in order to complete the reporting forms and collect information for the NTSB accident data base. These are discussed later in this section. The other project currently under development is a computerized checklist to be used at the site of an aircraft accident (Ryan, 1990). Sponsored by the FAA and the Transportation Safety Institute (TSI), this system would assist an aircraft accident investigator in the process of an investigation and would also perform other functions discussed later in this section.

Information Management

A primary function that can be performed by a computer in an accident investigation is the management of the information collected by the investigator. Information management is an umbrella term that covers the areas of information systems planning, data administration, systems

development, operations, and some aspects of end-user computing (Narayan, 1988). The task of information management is to manage the processing of information within an organization. This process requires storage and retrieval capabilities, so that data can be used for study and analysis at a later time (Fidel, 1987).

There have been close to 2,400 unique databases stored in the computers of about 345 retrieval services that offer online access to information to anyone with a computer terminal or personal computer and a modem that connects it to a telephone line (Humphrey & Melloni, 1986). Satellite data link communication can now be used for connections between databases and remote computer hardware, thus eliminating the need for telephone lines altogether (Sexton, 1988). These databases cover virtually all areas of knowledge: science, engineering, mathematics, medicine, agriculture, psychology, sociology, philosophy, law, business, economics, education, and more (Humphrey & Melloni, 1986).

Many databases are geared toward aviation safety. Both the FAA and NTSB keep accident and incident databases (Johnson, personal communication, August 26, 1991). Database information is used to derive statistics concerning different aspects of aircraft accidents. The FAA may wish to study a number of aircraft accidents that were caused by adverse weather conditions. By accessing the databases of

information previously entered into a computer, the statistics needed for such a study would be readily available.

In June 1990, the Aircraft Owners and Pilots Association (AOPA) Air Safety Foundation's (ASF) Emil Buehler Center for Aviation Safety completed the compilation of an aircraft accident database (Golbey, 1991). ASF's database now contains analyses of 16,220 accidents from 1982 to 1988 involving fixed-wing general aviation aircraft weighing less than 12,500 pounds. ASF recently released the first major product of the database, the General Aviation Accident Analysis Book - 1982 through 1988 (Golbey, 1991). This 586-page publication contains tables, charts, and graphs, accompanied by explanatory notes, and should serve as an invaluable aid to pilots and instructors (Golbey, 1991). All of the contents of this accident analysis book were derived from the ASF aircraft accident database. Other databases that the aviation community can access are the Federal Aviation Regulations and the Airman's Information Manual (AOPA, 1991).

The primary feature of the two previously mentioned projects currently under development at the NTSB and Embry-Riddle Aeronautical University (ERAU), is the accumulation of information collected at an aircraft accident site (Johnson, personal communication, August 26, 1991; Ryan, 1990). These databases, once developed will be used for

similar purposes as with the ASF. A computer used in accident investigation would also be able to access information in databases, as well as store information. The ability to dial up different databases, i.e., FAA Airman Records, FSS weather briefings and pilot briefings, aircraft system diagrams, etc., could be made available to the investigator at the accident site.

Information and its control and intelligent use is a prerequisite to achieving these aforementioned functions. One of the objectives of information management systems is to extend human capabilities (Diebold, 1985). This does not mean merely to lift or carry, but, more importantly, to communicate over distances further than earshot; to compensate for the vagaries of the human memory; to collect, manipulate, analyze, store, and retrieve information faster and more efficiently than previously possible. These earlier quite separate disciplines are converging into solution-oriented applied technology stems (Weil, 1982) and will play an increasingly important role in accident investigation in the future.

Reporting Form Completion

A primary use of the information stored in the databases is reporting form completion. Almost all accidents require some type of accident or summary report after the completion of the investigation (Ross, 1984). The reason for a reporting system is that events occur that

require explanation through a report. The depth and breadth of information will depend on what events are investigated. A review of current reporting systems indicates that the types of accidents formally investigated and reported indicate several factors. One, the more types of cases that are investigated, the greater will be the amount of information. Two, the broader the scope of the investigation, the more opportunity there is for finding more sources of harm (Ross, 1984).

The effort involved in producing accident reporting forms can be reduced significantly if done by a computer. Once initial information on an accident is input into a computer, the information can be compiled and printed in final form. Computerized accident forms are used by many companies, such as, Mobile Oil Corporation, American Broadcasting Company, and Construction Safety Association of Ontario (Ross, 1984).

Another example of computerized reporting form completion is the aforementioned FIRS/PC system used by FAA Security personnel when inspecting FAA facilities (DOT, 1990). Once information is input into a computer database by FAA Security personnel, the information is compiled and printed in the form of a summary report of activity.

The two ongoing projects previously mentioned are also being developed and designed to have a reporting form as a final product. The NTSB project will, once all information

has been entered by an investigator, print out the NTSB 6120.19A -Initial Aviation Accident Report, and the NTSB 6120.4 - Factual Report Aviation Accident/Incident (Johnson, personal communication, August 26, 1991). The project under development at Embry-Riddle Aeronautical University will also print out the NTSB 6120.19A and NTSB 6120.4.

Expert Systems

A further application of computers during aircraft accident investigation could be its assistance in the actual problem solving and decision making process. This would be done by incorporating the use of an expert system. Although expert systems are very complex to develop, the use of expert systems is becoming more prevalent in today's society.

The history of expert systems stems from the early work done with artificial intelligence (AI). These studies researched simple and powerful reasoning techniques that could be applied to different practical problems. Duda and Gaschnig (1985) stated that one popular approach to solving these problems has been to use IF-THEN rules. These rules say that if a certain kind of situation arises, a certain kind of action can be taken. For example, "IF an aircraft runs out of fuel, THEN the engine will stop." The knowledge captured within the rules and networks of expert systems is obtained by observing the behavior of the experts at work. Sometimes the experts are asked to explain how and on what

basis they make decisions in the tasks they perform. Answers pertaining to each specific scenario are then converted into explicit rules, amenable to computer-based information processing (Schutzer, 1985). The process of developing the production rules can be difficult and time consuming. The accuracy of the rules is dependent on the proficiency of the experts and the quality of the technical knowledge base existing for the subject. In addition, expert systems should be targeted to specific requirements. Conventional requirements analysis should thus precede the design and development of all interactive computer-based problem-solving systems (Andriole, 1985).

An expert usually has many judgmental or empirical rules according to which the evidence supports a conclusion or hypothesis, but with less than absolute certainty. In these cases, numerical values are associated with each rule to indicate the degree to which the hypothesis or conclusion follows from the evidence (Duda & Gaschnig, 1985).

Another type of system that is similar to an expert system is called a cooperative problem solving system. The major difference between classical expert systems and cooperative problem solving systems is that the human is much more an active agent and participant in the latter (Fischer, 1990). Traditional expert systems ask the user many questions and then return an answer. In a cooperative problem solving system the user and the system share the

problem solving and decision making, and different role distributions may be chosen depending on the user's knowledge, the user's goals, and the task domain. Fischer (1990) also stated that a cooperative system requires much richer communication facilities than the ones which were offered by traditional expert systems. Cooperative problem solving systems raise two important questions:

1. What part of the responsibility still has to be exercised by human beings?
2. How do we organize things so that the intelligent part of the automatic system can communicate effectively with the human part of the intelligent system?

Given these thoughts, cooperative problem solving systems might be deemed more beneficial to an aircraft accident investigator.

Expert systems are utilized in many different fields, ranging from diagnosing bacterial infections (Kulikowski, 1980; Pople, 1975) to choosing an optimum location for exploration of minerals (Duda, Gaschnig, & Hart, 1983). The application of an expert system for aircraft accident investigation is currently being researched at E-RAU, concurrently with the aforementioned computerized aircraft accident investigation (Ryan, 1990).

It is generally agreed that expert systems can be of enormous help to relatively inexperienced personnel, but are somewhat less helpful to highly experienced personnel. It

was also suggested that expert systems may be less applicable in some situations and for some users than in others (Ben-Bassat, 1985). But, expert systems can be very important in the distribution of knowledge. While the user might not necessarily need (or want) the help of an expert system, the less experienced personnel could benefit tremendously from interaction with an expert system designed by a cadre of highly experienced individuals (Ben-Bassat, 1985). Overall, the two primary advantages of an expert system are (a) to help experienced problem solvers check and re-check problem-solving processes and conclusions, and (b) to introduce many others to expertise not otherwise encountered (Andriole, 1985).

An information management system, together with an expert system and a data base, could be an asset to an aircraft accident investigator. An expert system could make available to the investigator engineering diagrams, airworthiness directives, report forms, and other information required for a successful investigation. By entering data as it is gathered into an expert system venue, the progress of the investigation can be realized and lead the investigator to incomplete information areas.

Ferry (1981) stated that we do not want to lose track of how an investigation is going and that the most thorough investigation is one of completeness. If the investigator has the time, resources, and permission to investigate

thoroughly, then all causal factors should be investigated until the investigation checklist is exhausted. An expert system would be an asset to this goal of completeness. By expediting the accident investigation process and reducing the redundancy of the steps taken, an expert system would assist in making the investigation sequence more efficient and more thorough.

Computer End-User Acceptance and Compatibility

As important as the investment in computer and communications facilities, however, is the investment in people to manage them (Diebold, 1985). When implementing a computer system, especially a new one, it is important that the end-users are introduced, effectively trained, and eventually accept the new technology. Although our lives are all touched by computers daily, many people have ambivalent feelings about them, either fearing them or exhibiting reluctance about interacting with them. Lee (1963) conducted one of the first studies concerning attitudes of end-users towards computers and found two orthogonal factors: the computer viewed as a beneficial tool of man; and as a superhuman thinking machine that downgrades man's previously unique significance in the order of things. Not only have computers changed dramatically since 1963, they have also become increasingly common.

A study by Zoltan (1982) examined the acceptance of computers by professional persons. In this study, the

attitudes of certified public accountants (CPAs), lawyers, pharmacists, and physicians toward computers were investigated. The results of this study showed not only a difference in opinions between the professions, but also in areas such as age and amount of previous computer training. Zoltan (1981) found, under the category of "computer experience", 69 percent of those professionals responding had never learned to use a computer. Zoltan (1981) also found for all professions combined, a disproportionately large number in the 20-29 year range had learned to use computers as compared to all other ten year age brackets. The Zoltan (1981) study findings will be compared and discussed later in this study.

Innovation and standardization are competing forces affecting virtually all aspects of the computer industry (Poltrock, 1989). The introduction and installing a computer to aid in the investigation of accidents would definitely be a disruption in the standard procedures now used by FAA ASIs. Principles in designing computer systems have been proposed that suggest how organizations might achieve successful innovation. Gould and Lewis (1983) proposed four principles of system design: (a) to understand the users and their tasks; (b) to include end-users on the design team; (c) to test the design by measuring the performance of end-users early in development; and (d) to iterate the design process. Three of these principles call

for involvement between intended users and system designers. Shneiderman (1987) observed that iterative design methods that allow early testing of prototypes, revision based on feedback from users, and incremental refinements suggested by test administrators are all necessary to arrive at a successful system. Hewett and Meadow (1986) also reported successfully using these principles in the design of systems. Gould and Lewis (1983) noted that these principles are not often followed even when developers thought they were obvious.

Both Shneiderman (1987) and Gould and Lewis (1983) recommended that intended users should be asked to carry out real work using prototypes early in the development process, and that the system should be interactively redesigned based on problems found in this testing. Other possible areas that should be researched prior to implementing a computer system are whether the system is effectively menu-driven (Barnhart, Habinek, & Savage, 1982) or command-driven, the readability of the text presented on the computer (Roemer & Chapanis, 1982), and the cognitive and affective interaction of the computer and end-user over time (Gilfoil, 1982) or how end-users actually learn to use a computer.

Overall, the history of the use of computers and their applications seems to have been successful. Research shows

that the use of computers has enhanced the different applications that have in the past been performed manually.

Design

A descriptive survey research method was used to investigate FAA ASIs' views on using a computer in the aircraft accident investigation process. This type of research method allowed for the examination of the topic through the use of a questionnaire. In this case, a questionnaire was used to survey the FAA ASIs on the topic of this study.

Sample Size

A number of factors may affect the sample size. In educational research, available resources of time, money, personnel, and facilities are often the most influential (Wiersma, 1991). Fortunately, these were not a factor in this study. Gay (1987) stated that for a descriptive research study, a sample size of 10 percent of the population is considered minimum. However, as Vockell (1983) stated, when a sample is used to estimate a population characteristic, the estimate is just that, an estimate. Vockell (1983) goes on to state the use of confidence intervals can determine the accuracy of the estimate. Confidence intervals can be applied to the sample estimate to indicate the range within which the population characteristic almost certainly falls. Confidence intervals

of $p < .05$ to $p < .10$ were targeted by the researcher ($p < .05$ confidence level) and a sample size estimate of 150 ASIs was selected. The following formula to calculate confidence interval limits at $p < .05$ confidence level was used:

$$\frac{1.96\sqrt{2500}}{\sqrt{n}}$$

(Vockell, 1983)

n = sample size.

With an estimated sample size of 150, the initial confidence intervals were calculated to be $p < .08$. The initial estimate was made more precise by utilizing a correction factor for instances when sample size is an important part of the population (more than 5% of the population). The percentage of the sample size to total population was therefore taken into consideration. The following formula was used to calculate the correction factor:

$$\sqrt{\frac{N-n}{N-1}}$$

(Vockell, 1983)

N = population size n = sample size.

The initial confidence intervals were multiplied by the calculated correction factor (.92), to obtain the adjusted confidence intervals of $p < .0736$. Therefore, the population characteristic in question would fall within the range of

$p < .0736$, when applied to the sample size estimate of 150. The confidence intervals of $p < .0736$ fell within the researcher's range of $p < .05$ to $p < .10$, therefore a sample size of 150 ASIs was confirmed for this study.

One hundred-fifty ASIs were randomly selected from the total list of ASIs who have graduated from the AAI-2 training, by use of a table of random numbers. Each member of the population was assigned a number (1-1,022) and 150 numbers were selected from the table, to be the subjects of this study (Gay, 1988; Vockell, 1991). Gay (1988) and Wiersma (1991) stated that to assure the validity of a descriptive survey research study, the minimum questionnaire response rate should be 70%. With 150 subjects in the study, the researcher felt that a response rate of 70% could be obtained and a goal of 75% was set.

Instrument

The measuring instrument utilized in this study was a self-developed survey questionnaire. This instrument was designed by the researcher for the specific purpose of exploring whether FAA Safety Inspectors believed that the use of a computer would help them in the investigation of aircraft accidents.

The validity and reliability of the questionnaire was determined by a pilot study conducted at TSI-AAI. TSI-AAI staff, a AAI-2 class (July 8-19, 1991), and other current aircraft accident investigation instructors, were asked to

answer and evaluate the questionnaire. A pilot study of a questionnaire provides the opportunity to identify confusing and ambiguous language, and to obtain information about possible results (Wiersma, 1991). After refining the questions, structure, content, etc., the final questionnaire was restructured and mailed, along with a cover letter signed by both the researcher and the Manager of the Aviation Safety Division at TSI (see Appendix A and B).

A Likert scale was utilized in the responses to most of the opinion questions. A Likert scale was used to register the extent of agreement or disagreement with a particular statement of an attitude, belief, or judgment (Tuckman, 1988). A Likert scale asks an individual to respond to a series of statements by indicating whether she or he strongly agrees, agrees, is undecided, disagrees, or strongly disagrees with each statement (Gay, 1987). This type of scale consists of a number of points on a scale, and the intervals between the points are assumed to be equal (Wiersma, 1991). The following designations were used in this study:

1. Strongly Agree (SA).....5
2. Agree (A).....4
3. Undecided (U).....3
4. Disagree (D).....2
5. Strongly Disagree (SD)....1

The point value listed next to the designation was used for totaling and analyzing the responses to formulate the results. The remaining opinion questions solicited either yes or no or multiple choice responses.

Additionally, the questionnaire solicited demographic data, for example, experience level, education level, area of expertise, age, and gender, to arrive at alternative reasons for differences in evaluating the use of a computer. The demographic questions were placed toward the end of the questionnaire, so as not to interrupt the transition from the cover letter to the primary questions of the study (Wiersma, 1991).

Procedure

Prior to the beginning of this study, the researcher obtained a listing of all FAA ASIs who had completed their aircraft accident investigation training. One hundred-fifty ASIs were randomly selected to participate in the study from this list. Prior to the main questionnaire being mailed, a draft questionnaire or pilot study was reviewed by TSI-AAI staff, current aircraft accident investigation instructors, and others in the aviation industry.

Once the questionnaire was refined to its final form, it was mailed to 150 randomly selected ASIs along with a cover letter explaining the purpose of the study. An overall goal of a 75 percent response rate was set to be met within a six week period. Once the returned questionnaires

were collected, the results were compiled into a data bank and the responses were categorized. A few cross-tabulations were performed using Chi-Square statistical analysis. The results were compared to the research hypothesis and based upon the results of the analysis, conclusions were drawn, and recommendations were made.

Data Analysis and Results

The following section contains the data collected from the survey questionnaire developed for this study. Each question in the questionnaire was analyzed and discussed. A sample of both the survey questionnaire and cover letter sent to the ASIs in the sample is contained in Appendix A and Appendix B, respectively.

The data in this study was analyzed using the statistical program AbStat. Totals and frequencies of the responses were calculated for all variables and a Chi-square test was performed for selected cross-tabulations. In the tables that follow, the number of responses to each question (N) are listed under the respective category and the percentages are adjacent to the respective number of responses in parenthesis (%). The total number of responses per survey question may vary due to the ASIs in the sample not responding to every question.

There were 150 questionnaires distributed to the potential respondents. Two questionnaires were returned unopened due to termination of employment of the ASI with the FAA. Therefore, the final sample size was 148. By September 27, 1991, 122 questionnaires or 82% were returned; one was not completed. The percentage of returned

questionnaires exceeded both the 70% minimum sample return (Gay, 1987) and the initial goal of the researcher of 75%.

Demographic Questions

The following seven tables display the data used to establish the characteristics of the sample of ASIs in this study. As shown in Table 1, the majority of the sample were males, 113 or 95.0%, while 6 or 5.0% were females.

Table 1

Responses to Survey Question 22

Gender of Aviation Safety Inspectors.

| Male | | Female | |
|------|--------|--------|-------|
| N | % | N | % |
| 113 | (95.0) | 6 | (5.0) |

The age ranges of the ASIs in the sample are represented in Table 2. Forty-five or 37.8% of the sample

Table 2

Responses to Survey Question 23

Age of Aviation Safety Inspectors.

| Under 30 | | 30-39 | | 40-49 | | 50 or More | |
|----------|--------|-------|--------|-------|--------|------------|--------|
| N | % | N | % | N | % | N | % |
| 0 | (0.00) | 20 | (16.8) | 54 | (45.4) | 45 | (37.8) |

were 50 years of age or older and 54 or 45.4% were between 40 and 49 year of age, resulting in 83.2% of the ASIs in the sample being 40 years of age or older. Twenty ASIs or 16.8% of the sample were between 30 and 39 years of age and none of the ASIs in the sample were under 30 years of age. Cross tabulations were done on age and specific opinions and are stated later in the next section of the study.

Question 24 surveyed the ASIs in the sample on their highest educational degree earned. Table 3 shows 51 or 42.9% of the ASIs had earned a high school degree and 36 or 30.3% had earned some type of Associate's degree. Bachelor's degrees were earned by 23 or 19.3% of the ASIs in the sample, while seven or 5.9% and two or 1.7% of the ASIs earned Master's degrees and Doctorate degrees, respectively.

Table 3

Responses to Survey Question 24

Highest degree earned by Aviation Safety Inspectors.

| High School | | Associate's | | Bachelor's | | Master's | | Doctorate | |
|-------------|--------|-------------|--------|------------|--------|----------|-------|-----------|-------|
| N | % | N | % | N | % | N | % | N | % |
| 51 | (42.9) | 36 | (30.3) | 23 | (19.3) | 7 | (5.9) | 2 | (1.7) |

Although the sample was randomly selected, certain regions were represented more often than others (Question 21). Table 4 shows the Southern (24 ASIs or 20.2%), Northwest (23 ASIs or 19.3%), and Western-Pacific (23 ASIs

or 19.3%) regions were the top three regions represented in the sample (see Table 11). The remainder of the regions were represented as follows: (a) Great Lakes region (13 ASIs or 10.9%); (b) Central, Eastern, and Southwest regions (9 ASIs each or 7.6% each); (c) New England region (6 ASIs or 5.0%); and (d) Alaskan region (3 ASIs or 2.5%).

Table 4

Responses to Survey Question 21

What FAA region to you work in?

| Region | N | % |
|--------------------|----|--------|
| Southern | 24 | (20.2) |
| Northwest-Mountain | 23 | (19.3) |
| Western-Pacific | 23 | (19.3) |
| Great Lakes | 13 | (10.9) |
| Central | 9 | (7.6) |
| Eastern | 9 | (7.6) |
| Southwest | 9 | (7.6) |
| New England | 6 | (5.0) |
| Alaskan | 3 | (2.5) |

Table 5 illustrates the breakdown of specializations of the ASIs in the sample. General Aviation Airworthiness Inspectors represented the highest percentage of the sample, 35 ASIs or 30.2%. Air Carrier Airworthiness (27 ASIs or 23.3%) and General Aviation Operations (25 or 21.6%), respectively, were the next highest of the specializations

represented. These were followed by Avionics (14 ASIs or 12.1%) and Air Carrier Operations (13 ASIs or 11.2%). One or .9% of the sample was an Accident Prevention Program Manager and one or .9% was an office supervisor.

Table 5

Responses to Survey Question 20

Specializations of ASIs in the sample.

| GA Ops | | AC Ops | | GA A/W | | AC A/W | | AVN | | APPM | | Other | |
|--------|--------|--------|--------|--------|--------|--------|--------|-----|--------|------|--------|-------|--------|
| N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| 25 | (21.6) | 13 | (11.2) | 35 | (30.2) | 27 | (23.3) | 14 | (12.1) | 1 | (0.09) | 1 | (0.09) |

Note. GA Ops--General Aviation Operations
 GA A/W--General Aviation Airworthiness
 AC Ops--Air Carrier Operations
 AC A/W--Air Carrier Airworthiness
 AVN--Avionics
 APPM--Accident Prevention Program Manager

The responses to Question 11 concerned the number of years employed as an aircraft accident investigator. Table 6 shows that of the 121 ASIs, 76% had six years or less as an aircraft accident investigator. Further breakdown of the data showed 45 ASIs or 37.2% had one to three years investigation experience, while 47 or 38.8% of the ASIs had four to six years investigation experience. Of the remaining 24% of the sample, 12 or 9.9% had seven to nine

years investigation experience and 17 or 14.1% had ten or more years of experience in aircraft accident investigation.

Table 6

Responses to Survey Question 11

Number of years as an aviation accident investigator?

| 1-3 years | | 4-6 years | | 7-9 years | | 10+ years | |
|-----------|--------|-----------|--------|-----------|-------|-----------|--------|
| N | % | N | % | N | % | N | % |
| 45 | (37.2) | 47 | (38.8) | 12 | (9.9) | 17 | (14.1) |

To complement the question concerning the number of years as an aircraft accident investigator (Question 11), the sample of ASIs was surveyed on the number of accident investigations performed (Question 12). The data, as shown in Table 7, indicated 45 or 37.2% of the ASIs polled had performed ten or more investigations. Thirty-two or 26.4%

Table 7

Responses to Survey Question 12

How many accident investigations have your performed?

| 0 | | 1-5 | | 6-10 | | 10+ | |
|---|-------|-----|--------|------|--------|-----|--------|
| N | % | N | % | N | % | N | % |
| 4 | (3.3) | 40 | (33.1) | 32 | (26.4) | 45 | (37.2) |

of the sample had performed six to ten investigations and 40 or 33.1% of the ASIs had only performed one to five investigations. The remaining four ASIs (3.3%) had not

performed any accident investigations. Comparing the data in Table 2 with the data in Table 1 seems to show, even though 76% of the ASIs polled had been aircraft accident investigators for six or less years, over half of them (63.6%) had performed six investigations or more.

Cross-Tabulations

To determine whether there were any significant differences between the opinion of the respondents as a function of demographic factors, a number of cross-tabulations were performed. More specifically, Survey Question 1 regarding whether the ASIs felt comfortable using a personal computer (see Table 18) was compared with the following questions: (a) Survey Question 23--Age of the ASI (see Table 2); (b) Survey Question 24--Highest degree earned by the ASI (see Table 3); and (c) Survey Question 25--Formal computer instruction (see Table 15). A null hypothesis was stated for each of the cross-tabulations and a Chi-square test was performed on each. Due to the use of nominal data, a Chi-square test of independence was the appropriate data analysis procedure in this case. (Hinkle, Jurs, & Wiersma, 1979)

Feeling comfortable using a computer versus age. A cross-tabulation was conducted between Survey Question 1 and Survey Question 23. The two variables of whether or not the ASIs in the sample "felt comfortable using a computer to carry out their job functions" and their "age" were

compared. A null hypothesis was stated that there was no significant difference between whether or not the ASIs in the sample felt comfortable using a personal computer and their age; or that the ASIs felt comfortable using a personal computer was independent of their ages. Using a 3 x 5 contingency table, the Chi-square value was calculated to be 6.864. At the $p < .05$ level of significance and eight degrees of freedom, the critical value of Chi-square was 15.507. Since the calculated value of Chi-square was less than the critical value, the null hypothesis that there was no significant difference between the two variables is accepted. Whether or not the ASIs in the sample felt comfortable using a personal computer in carrying out their job function was independent of their age.

Feeling comfortable using a computer versus highest degree earned. Another cross-tabulation was performed between Survey Question 1 and Survey Question 24. The two variables involved were whether or not the ASIs in the sample "felt comfortable using a personal computer in carrying out their job functions" and the "highest degree earned." A null hypothesis was stated that there was no significant difference between whether or not the ASIs in the sample felt comfortable using a personal computer and their highest degree earned; or that the ASIs felt comfortable using a personal computer was independent of their highest degree earned. Using a 5 x 5 contingency

table, the Chi-square value was calculated to equal 19.505. At the $p < .05$ level of significance and 16 degrees of freedom, the critical value of Chi-square was 26.296. Since the calculated value of Chi-square was less than the critical value, the null hypothesis that there was no significant difference between the two variables is accepted. Whether or not the ASIs in the sample felt comfortable using a personal computer in carrying out their job function was independent of the highest degree they had earned.

Feeling comfortable using a computer versus formal computer instruction received. The final cross-tabulation of this study was conducted between Survey Question 1 and Survey Question 25. This cross-tabulation compared whether or not the ASIs in the sample "felt comfortable using personal computer to carry out their job functions" with whether they had received "any formal computer instruction." The null hypothesis was stated that there was no significant difference between whether the ASIs felt comfortable in using a computer and whether they had received any formal computer training; or that the ASIs felt comfortable using a computer was independent of whether they had received any formal computer instruction. Using a 2 x 5 contingency table, the Chi-square value was calculated to be 1.195. At the $p < .05$ level of significance and four degrees of freedom, the critical value of Chi-square was 9.488. Since the

calculated value of Chi-square was less than the critical value, the null hypothesis that there was no significant difference between the two variables is accepted. Whether or not the ASIs in the sample felt comfortable using a personal computer in carrying out their job function was independent of whether they had received any formal computer instruction.

Opinion Questions

The following tables contain the data for the questions in the survey soliciting the ASIs' opinions. These questions focus on the primary theme of the use of a computer during the accident investigation process.

In answering the question on the method used to collect data at an aircraft accident site (Question 13), Table 8 shows the majority (77 or 70.6%) of the ASIs in the sample

Table 8

Responses to Survey Question 13

What is your primary means of collecting information at an accident site? (please rank 1, 2, 3....)

| Clipboard | | Tape Recorder | | Camera | | Video Camera | | Laptop\ Pen PC | | Other | |
|-----------|--------|---------------|-------|--------|--------|--------------|-------|----------------|--------|-------|--------|
| N | % | N | % | N | % | N | % | N | % | N | % |
| 77 | (70.6) | 6 | (5.5) | 23 | (21.1) | 3 | (2.8) | 0 | (0.00) | 0 | (0.00) |

indicated their primary means of collecting data at an accident site was a clipboard. Six or 5.5%, and 23 or

21.1%, used a tape recorder and camera, respectively. Of the other possible answers, three ASIs or 2.8% used a video camera, and no one in the sample used a notebook or pen-type personal computer to collect data at a site. There were no responses to the "Other" category.

Table 9 shows 89 or 76.2% of the ASIs polled use a computer when dealing with an aircraft accident investigation (Question 14). Twenty-seven or 23.3% of the sample did not use a computer when conducting accident investigations.

Table 9

Responses to Survey Question 14

Do you use a computer when dealing with accident investigations at the present time?

| Yes | | No | |
|-----------|---|-----------|---|
| N | % | N | % |
| 89 (76.8) | | 27 (23.3) | |

Although the data in Table 9 shows 76.8% of the sample use a computer when dealing with accident investigations, Table 10 indicates 117 ASIs or 99.1% of those surveyed do not use a computer at the accident site. Only one percent of the sample use a computer on site.

Table 10

Responses to Survey Question 15

Do you currently use a personal computer at an accident site?

| Yes | | No | |
|-----|-------|-----|--------|
| N | % | N | % |
| 1 | (0.9) | 117 | (99.1) |

Table 11 shows the major concern of the ASIs in the sample with regards to using a computer at an accident site (Question 16) was the "weight" of a computer (N = 78) and its "protection from environmental elements" (N = 78).

"Size" was the next major concern of the ASIs (N = 66), followed by difficulty of data input (N = 58). "Risk of damage" to the computer earned 46 points, while "loss of memory" received 42 points. The categories of "shape" (N = 18) and "other" (N = 16) were less of a concern to the sample of ASIs than the other response categories.

For Question 16 (Table 11), one point was given to every response the ASIs listed as a concern. These points were tabulated and the totals are listed per response (N) in this table. Some ASIs circled only one response and others circled multiple responses as was the option listed in the question.

Table 11

Responses to Survey Question 16

_____ would be my concern(s) in using a personal computer at an accident site. (circle all that apply)

| Item | N |
|--|----|
| Weight | 78 |
| Protection from environmental elements | 78 |
| Size | 66 |
| Difficulty of data input | 58 |
| Risk of damage | 46 |
| Loss of memory | 42 |
| Shape | 18 |
| Other | 16 |

In responding to Question 17 concerning the area of computer application (see Table 12), the ASIs in the sample indicated that data collection (32 ASIs or 33.7%) and report form completion (30 ASIs or 31.6%) would be most beneficial.

Table 12

Responses to Survey Question 17

What area of application do you think a computer would be most beneficial in accident investigation? (circle one)

| Information Retrieval | | Data Collection | | Data Analysis | | Report Form Completion | | Other | |
|-----------------------|--------|-----------------|--------|---------------|-------|------------------------|--------|-------|-------|
| N | % | N | % | N | % | N | % | N | % |
| 22 | (23.2) | 32 | (33.7) | 9 | (9.5) | 30 | (31.6) | 2 | (2.1) |

Information retrieval ranked third, with 22 or 23.2% of the ASIs. Data analysis and other applications combined for the remaining 11 or 11.6% of the sample.

In responding to Survey Question 18, 89 or 75.4% of the ASIs in the sample had access to a personal computer in their office (see Table 13). Twenty-nine or 24.5% of the sample responded they had no access to a personal computer in their office.

Table 13

Responses to Survey Question 18

Do you have access to a personal computer in your office?

| Yes | | No | |
|-----------|---|-----------|---|
| N | % | N | % |
| 89 (75.4) | | 29 (24.5) | |

For the ASIs responding "yes" to Question 18 (see Table 13), 33 or 37.5% answered they used a computer several times per day (see Table 14). Twenty-three or 26.1% used a computer at least once per day. The remainder of the sample indicated they used a computer at least once a week (16 ASIs or 18.2%) or less than once a week (16 ASIs or 18.2%).

Table 14

Responses to Survey Question 19

If you answered yes to #18, how often do you use the computer in the office?

| Several Times per Day | | At Least Once per Day | | At Least Once per Week | | Less Than Once a Week | |
|--------------------------|--------|--------------------------|--------|---------------------------|--------|--------------------------|--------|
| N | % | N | % | N | % | N | % |
| 33 | (37.5) | 23 | (26.1) | 16 | (18.2) | 16 | (18.2) |

Table 15 shows the responses to the question concerning whether or not any formal computer instruction was received (Question 25) by the ASIs in the sample. Of the 119 ASIs in

Table 15

Responses to Survey Question 25

Have you received any formal computer instruction?

| Yes | | No | |
|-----|--------|----|--------|
| N | % | N | % |
| 69 | (58.0) | 50 | (42.0) |

the sample responding to this question, 69 or 58% had received formal computer instruction, while 50 or 42.0% had not received any formal computer instruction.

Question 26 surveyed the ASIs on whether they used a personal computer in their previous job. Forty-five or 37.8% of the ASIs indicated they did use a computer in one

of their past jobs. In contrast, 74 or 62.2% responded they did not use a personal computer in a previous job.

Table 16

Responses to Survey Question 26

Did you use a personal computer in your previous job?

| Yes | | No | |
|-----|--------|----|--------|
| N | % | N | % |
| 45 | (37.8) | 74 | (62.2) |

In addition to whether the ASIs used a personal computer in their previous job, they were also surveyed on whether they used a personal computer in their home. Fifty-six or 47.1% of the respondents listed they do use a personal computer at home. Sixty-three or 52.9% of the sample indicated they do not use a personal computer at home.

Table 17

Responses to Survey Question 27

Do you use a personal computer at home?

| Yes | | No | |
|-----|--------|----|--------|
| N | % | N | % |
| 56 | (47.1) | 63 | (52.9) |

The remaining ten tables of data list the responses to the opinion questions in the survey. The raw data and tabulations for Questions 1-10 are also listed in Appendix C. Table 18 shows 86 or 71% of the ASIs in the sample agree that they feel comfortable using a computer to carry out their job functions. A further breakdown indicates 40 or

Table 18

Responses to Survey Question 1

I feel comfortable using a personal computer to carry out my job functions.

| Strongly Agree | | Agree | | Undecided | | Disagree | | Strongly Disagree | |
|----------------|--------|-------|--------|-----------|--------|----------|--------|-------------------|-------|
| N | % | N | % | N | % | N | % | N | % |
| 40 | (33.1) | 46 | (38.0) | 16 | (13.2) | 14 | (11.6) | 5 | (4.1) |

33.1% strongly agree that they feel comfortable using a computer and 46 or 38.0% agree with the same. Sixteen or 13.2% of the ASIs were undecided on the question, while 19 or 15.7% disagreed or strongly disagreed with the statement (14 or 11.6% and five or 4.1%, respectively).

In responding to Survey Question 2, 34 or 28.1% of the ASIs in the sample indicated they strongly agree and 45 or 37.5% agreed that if screens exhibited specific checklists to collect information and were displayed on a computer at an accident site, they would find these screens easier to use than current methods of data collection (see Table 19).

Twenty-four or 20.0% of the sample were undecided on this statement, while 17 or 14.2% (12 or 10.0% and five or 4.2%, respectively) stated they disagree that exhibited screens would be helpful.

Table 19

Responses to Survey Question 2

If screens exhibited specific checklists to collect information and were displayed on a computer at an accident site, I would find these screens easier to use than current methods of data collection.

| Strongly Agree | | Agree | | Undecided | | Disagree | | Strongly Disagree | |
|----------------|--------|-------|--------|-----------|--------|----------|--------|-------------------|-------|
| N | % | N | % | N | % | N | % | N | % |
| 34 | (28.1) | 45 | (37.5) | 24 | (20.0) | 12 | (10.0) | 5 | (4.2) |

Note. One respondent did not answer this question.

Survey Question 3 asked the ASIs in the sample if they could spend more time on contributing factors and recommendations on how to prevent future problems or accidents if a computer was used to complete certain parts of an accident investigation (see Table 20). Twenty-two or 18.3% of the sample strongly agreed and 58 or 48.3% agreed with this statement. Twenty-four or 20.0% of the ASIs responded they were undecided on this matter. Of the remaining respondents, 13 or 10.8% disagreed with the statement, while three or 2.3% responded strongly disagree.

Table 20

Responses to Survey Question 3

I could spend more time on contributing factors and recommendations if a computer was used to complete certain parts of an investigation.

| Strongly Agree | | Agree | | Undecided | | Disagree | | Strongly Disagree | |
|----------------|--------|-------|--------|-----------|--------|----------|--------|-------------------|-------|
| N | % | N | % | N | % | N | % | N | % |
| 22 | (18.3) | 58 | (48.3) | 24 | (20.0) | 13 | (10.8) | 3 | (2.5) |

Note. One respondent did not answer this question.

Table 21 displays the data collected on Survey Question 4. This question inquired if a computer were made available

Table 21

Responses to Survey Question 4

If a computer were made available to collect as much information about an accident prior to leaving for an accident site, I would utilize such a tool.

| Strongly Agree | | Agree | | Undecided | | Disagree | | Strongly Disagree | |
|----------------|--------|-------|--------|-----------|-------|----------|-------|-------------------|-------|
| N | % | N | % | N | % | N | % | N | % |
| 50 | (41.3) | 51 | (42.1) | 11 | (9.1) | 7 | (5.8) | 2 | (1.7) |

to collect as much information about an accident prior to leaving for an accident site, ASIs would utilize such a tool. Over 80% of the ASIs in the sample agreed that they would use a computer as a tool to aid in their

investigation. More specifically, 50 or 43.1% of the sample strongly agreed and 51 or 42.1% of the sample agreed.

Eleven or 9.1% of the ASIs in the sample were undecided on this question. Nine or 7.5% of the ASIs disagreed that they would use a computer as an investigative tool (seven or 5.8% disagreed and two or 1.7% strongly disagreed).

Fifty-one or 42.1% of the ASIs in the sample strongly agreed and 48 or 39.7% agreed having as much information as possible prior to leaving for the accident site would reduce the time and energy spent on an accident investigation by an investigator (see Table 22). Eleven or 9.1% were undecided

Table 22

Responses to Survey Question 5

Having as much information as possible prior to leaving for the accident site would reduce the time and energy spent on an accident investigation by an investigator.

| Strongly Agree | | Agree | | Undecided | | Disagree | | Strongly Disagree | |
|----------------|--------|-------|--------|-----------|-------|----------|-------|-------------------|-------|
| N | % | N | % | N | % | N | % | N | % |
| 51 | (42.1) | 48 | (39.7) | 11 | (9.1) | 9 | (7.4) | 2 | (1.7) |

on the statement, while nine or 7.4% disagreed and two or 1.7% strongly disagreed having as much information as possible would reduce the time spent on an investigation.

Forty-seven or 38.8% of the sample strongly agreed with Survey Question 6 that if a personal computer were made

available, ASIs would use it during the aircraft accident investigation process (see Table 23). Also, in support of this idea, 45 or 37.2% of the ASIs in the sample agreed with this statement. In contrast, five or 4.1% disagreed and three or 2.5% strongly disagreed they would use a computer if available. Twenty-one or 17.4% of the respondents were undecided on this matter.

Table 23

Responses to Survey Question 6

If a personal computer were made available, I would use it during the aircraft accident investigation process.

| Strongly Agree | | Agree | | Undecided | | Disagree | | Strongly Disagree | |
|----------------|--------|-------|--------|-----------|--------|----------|-------|-------------------|-------|
| N | % | N | % | N | % | N | % | N | % |
| 47 | (38.8) | 45 | (37.2) | 21 | (17.4) | 5 | (4.1) | 3 | (2.5) |

Survey Question 7, as shown in Table 24, polled the sample of ASIs on if a lightweight, portable personal computer were made available, they would take it to the accident site, as opposed to taking the computer to a hotel or car close to the site. Sixty-five or 74.2% of the ASIs in the sample agreed they would take a computer to the accident site (24 or 20.0% strongly agreed and 41 or 34.2% agreed. Thirty or 25.0% of the sample were undecided, while 17 or 14.2% disagreed and eight or 6.7% strongly disagreed.

Table 24

Responses of Survey Question 7

If a lightweight, portable personal computer were made available, I would take it to the accident, as opposed to taking the computer to a hotel or car close to the site.

| Strongly Agree | | Agree | | Undecided | | Disagree | | Strongly Disagree | |
|----------------|--------|-------|--------|-----------|--------|----------|--------|-------------------|-------|
| N | % | N | % | N | % | N | % | N | % |
| 24 | (20.0) | 41 | (34.2) | 30 | (25.0) | 17 | (14.2) | 8 | (6.7) |

Note. One respondent did not answer this question.

In responding to Survey Question 8 (see Table 25) regarding whether the ASIs in the sample felt if a computer

Table 25

Responses to Survey Question 8

I feel that if a computer were used to collect accident data and complete the accident report forms during the investigation, more time could be devoted to the other responsibilities of an Aviation Safety Inspector.

| Strongly Agree | | Agree | | Undecided | | Disagree | | Strongly Disagree | |
|----------------|--------|-------|--------|-----------|--------|----------|-------|-------------------|-------|
| N | % | N | % | N | % | N | % | N | % |
| 44 | (36.4) | 48 | (39.7) | 15 | (12.4) | 9 | (7.4) | 5 | (4.1) |

were used to collect accident data and complete the accident report forms during the investigation, more time could be devoted to the other responsibilities of an Aviation Safety Inspector, over 76% of the sample agreed. Forty-four or

36.4% of the ASIs in the sample strongly agreed and 48 or 39.7% agreed with this statement. Dissimilarly, nine or 7.4% of the sample disagreed with the statement, while five or 4.1% strongly disagreed. Fifteen or 12.4% were undecided on this matter.

Survey Question 9 stated, "the use of an expert system in aircraft accident investigation is also being looked at under this study. After initial accident information was entered, an expert system would suggest possible contributing factors. I would accept these contributing factors presented and investigate them further." Table 26 shows that 26 or 21.5% strongly agreed and 61 or 50.4% of

Table 26

Responses to Survey Question 9

The use of an expert system in aircraft accident investigation is also being looked at under this study. After initial accident information was entered, an expert system would suggest possible contributing factors. I would accept these contributing factors presented and investigate them further.

| Strongly Agree | | Agree | | Undecided | | Disagree | | Strongly Disagree | |
|----------------|--------|-------|--------|-----------|--------|----------|-------|-------------------|-------|
| N | % | N | % | N | % | N | % | N | % |
| 26 | (21.5) | 61 | (50.4) | 25 | (20.7) | 6 | (5.0) | 3 | (2.5) |

the ASIs in the sample agreed with this statement. Twenty-five or 20.7% of the sample were undecided on the use of an expert system, while nine or 7.5% disagreed with the use of

such a system (six or 5.0% disagreed and three or 2.5% strongly disagreed).

Seventy-six percent of the ASIs in the sample indicated they thought a personal computer would be a useful tool in training new Aviation Safety Inspectors in the procedures and techniques of aircraft accident investigation. As shown in Table 27, 42 or 34.7% of the ASIs strongly agreed, while 50 or 41.3% of the sample agreed that a personal computer would make a good training tool. Ten or 8.3% of the ASIs in

Table 27

Responses to Survey Question 10

A personal computer would be a useful tool in training new Aviation Safety Inspectors in the procedures and techniques of aircraft accident investigation.

| Strongly Agree | | Agree | | Undecided | | Disagree | | Strongly Disagree | |
|----------------|--------|-------|--------|-----------|--------|----------|-------|-------------------|-------|
| N | % | N | % | N | % | N | % | N | % |
| 42 | (34.7) | 50 | (41.3) | 19 | (15.7) | 6 | (5.0) | 4 | (3.3) |

the sample did not agree a computer would make a good training medium (six or 5.0% disagreed and four or 3.3% strongly disagreed). Nineteen or 15.7% of the sample were undecided on the topic.

Conclusions and Recommendations

Conclusions

It was hypothesized that aircraft accident investigators in the sample would think that the use of a computer would help them with accident report form completion, managing accident data collected, and in determining factors contributing to an accident. It was further hypothesized, with a computer handling different elements of the aircraft accident investigation process, the ASIs in the sample would think that the process would become more efficient. The data from this study strongly supports this hypothesis.

The following conclusions were derived from the data collected:

1. "Weight" and "protection from the environment" (adverse weather, terrain, temperature, etc.) were the major concerns of ASIs in using a personal computer at an aircraft accident site. Since all aircraft accidents do not occur within airport boundaries, but possibly in remote, hard to reach areas, any extra equipment could become cumbersome. Several ASIs from the Northwest-Mountain region indicated in the "additional comments" section of the survey questionnaire, that they do not take anything that is not

absolutely necessary to a remote aircraft accident site. The third highest concern of the ASIs in the sample was "size."

2. Most (76.8%) ASIs use a computer when dealing with aircraft accident investigations at the present time, although almost all (99.1%) do not use a computer at an accident site. This would seem to indicate a computer is only used during investigations either at an ASI's office or at a hotel or staging area near the accident site.

3. ASIs think the most beneficial application of a computer in the aircraft accident investigation process would be data collection, followed by report form completion.

4. Most ASIs (75.4%) in the FAA have access to a computer and use it at least once a day.

5. Over half of the FAA ASIs (58.0%) have had formal computer instruction of some type.

6. Over half of the FAA ASIs (62.2%) did not use a computer in their previous job.

7. Most ASIs (71.1%) feel comfortable using a personal computer in carrying out their job functions.

8. Over half of the FAA ASIs (65.6%) agree if screens exhibited specific checklists to collect information and were displayed on a computer at an accident site, they would find these screens easier to use than current methods of data collection.

9. Over half of the FAA ASIs (61.6%) believe they could spend more time on contributing factors and recommendations derived from an aircraft accident investigation if a computer were used to complete certain parts of an investigation.

10. Most ASIs (83.4%) think if a computer were made available to collect as much information as possible about an accident prior to leaving for an accident site, they would utilize such a tool.

11. Most ASIs (81.8%) believe having as much information as possible prior to leaving for an accident site would reduce the time and energy spent on an accident investigation by an investigator.

12. Most ASIs (76.0%) would use a personal computer during an aircraft accident investigation, if it were made available.

13. Over half of the FAA ASIs (54.2%) would take a lightweight personal computer to an accident site, as opposed to only taking it to a hotel or staging area close to the accident site.

14. Most ASIs (76.1%) feel if a computer were used to collect accident data and complete the accident report forms during an investigation, more time could be devoted to the other responsibilities of an Aviation Safety Inspector.

15. Most ASIs (71.9%) agree if an expert system suggested possible contributing factors, they would accept

the contributing factors presented and investigate them further.

16. Most ASIs (76.0%) agree a personal computer would be a useful tool in training new ASIs in the procedures and techniques of aircraft accident investigation.

Cross-tabulations in this study showed the following conclusions:

1. There was no significant difference between the ASIs "feeling comfortable with using a computer" and their "age." These findings were different from those presented by Zoltan (1985), in which there was a significant difference in the use of computers and the age of the users.

2. There was no significant difference between the ASIs "feeling comfortable with using a computer" and their "highest degree" earned.

3. There was no significant difference between the ASIs "feeling comfortable with using a computer" and whether or not they had had any "formal computer instruction."

Overall, the data strongly suggests that ASIs support the use of a personal computer to assist in the aircraft accident investigation process and that the investigative process would be made more efficient if a personal computer was used.

Recommendations

Ferry (1988) stated that computers cannot replace investigators, but computers will lend a hand and enable us to do a more efficient job with better results. The results and conclusions of this study support Ferry's view. It is the researcher's opinion that computers will never replace aircraft accident investigators. On the other hand, computers could possibly be a valuable asset to the aircraft accident investigation community. Mucho (1990) stated that field investigators are frequently discouraged by the overall process due to lack of time, feedback, and availability of research material. As the data from this study suggest, current aircraft accident investigators would support the use of personal computers to assist in the different elements of the investigation process.

Based on the literature review, the results, and conclusions of this study, the following recommendations to the aircraft accident investigation community were made:

1. Develop a computer system to perform the functions of accident report form completion, to manage information (data collection and information retrieval), and to help in determining possible contributing factors of an accident.
2. Develop a computer system that can be taken into the field at an accident site.
3. Develop a computer system/program to be used as a training tool for new aircraft accident investigators. This

program should be similar to the one developed for actual aircraft accident investigation.

4. Develop an expert system to assist aircraft accident investigators in performing aircraft accident investigations.

Suggestions for Further Study

Based on the research performed and the conclusions made in this study, the following suggestions for further research were made:

1. This study sampled a few of the many aspects involved in the aircraft accident investigation process. Each one of these areas, i.e., accident report form completion, information retrieval, data collection (on and off site), should be studied and researched separately.

2. The use of a personal computer at an aircraft accident site should be field tested. These tests should include comparing and contrasting different hardware applications and human interface and acceptance experiments.

3. Further research should be performed on the use of expert systems in aircraft accident investigation.

4. Different computer usability concerns per region should be compared and contrasted.

5. Further cross-tabulations should be performed on other variables in the survey questionnaire used in this study:

a. ASIs "region" versus "primary concern for using a computer at an accident site."

b. The "number of years as an aircraft accident investigator" and "if a personal computer were made available, I would use it during the aircraft accident investigation process."

c. The "number of years as an aircraft accident investigator" and whether or not an ASI would "accept suggestions of contributing factors from an expert system and investigate the factors further."

6. Further work should be performed to study different ways to make the aircraft accident investigation process more efficient.

The researcher believes that making improvements in aviation safety depends partly on the recommendations that stem from aircraft accident investigations. As shown, aircraft accident investigators support the use of computers to assist the accident report form completion, data collection, and deriving contributing factors, thus making the accident investigation process more efficient. If the process of accident investigations could be made more efficient, investigators could possibly spend more time on the quantity and quality of safety recommendations, which should help prevent future aircraft accidents.

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APPENDIX A
SURVEY QUESTIONNAIRE

Computerized Aviation Accident Investigation Questionnaire

Please answer the following questions by circling your selection, according to the following key (where appropriate):

SA = Strongly Agree
 A = Agree
 U = Undecided
 D = Disagree
 SD = Strongly Disagree

Please feel free to add any relevant comments pertaining to the questions. Remember, all of your responses will be kept confidential. However, if you do not feel comfortable answering a particular question, please feel free to skip the questions. Please circle only one response per question, unless stated otherwise.

- | | | | | | |
|--|----|---|---|---|----|
| 1. I feel comfortable using a personal computer to carry out my job functions. | SA | A | U | D | SD |
| 2. If screens exhibited specific checklists to collect information and were displayed on a computer at an accident site, I would find these screens easier to use than current methods of data collection. | SA | A | U | D | SD |
| 3. I could spend more time on contributing factors and recommendations if a computer was used to complete certain parts of an investigation. | SA | A | U | D | SD |
| 4. If a computer were made available to collect as much information about an accident prior to leaving for an accident site, I would utilize such a tool. | SA | A | U | D | SD |

- | | | | | | |
|---|----|---|---|---|----|
| 5. Having as much information as possible prior to leaving for the accident site would reduce the time and energy spent on an accident investigation by an investigator. | SA | A | U | D | SD |
| | | | | | |
| 6. If a personal computer were made available, I would use it during the aircraft accident investigation process. | SA | A | U | D | SD |
| | | | | | |
| 7. If a lightweight, portable personal computer were made available, I would take it to the accident site, as opposed to taking the computer to a hotel or car close to the site. | SA | A | U | D | SD |
| | | | | | |
| 8. I feel that if a computer were used to collect accident data and complete the accident report forms during the investigation, more time could be devoted to the other responsibilities of an Aviation Safety Inspector. | SA | A | U | D | SD |
| | | | | | |
| 9. The use of an expert system in aircraft accident investigation is also being looked at under this study. After initial accident information was entered, an expert system would suggest possible contributing factors. I would accept these contributing factors presented and investigate them further. | SA | A | U | D | SD |

10. A personal computer would be a useful tool in training new Aviation Safety Inspectors in the procedures and techniques of aircraft accident investigation. SA A U D SD
11. Number of years as an aviation accident investigator:
- a. 1-3
 - b. 4-6
 - c. 7-9
 - d. 10 or more
12. How many accident investigations have you performed?
- a. 0
 - b. 1-5
 - c. 6-10
 - d. more than 10
13. What is your primary means of collecting information at an accident site? (please rank 1, 2, 3....)
- _____ clipboard (pad and pen/pencil)
 - _____ tape recorder
 - _____ camera
 - _____ video camera
 - _____ laptop or pen-type computer
 - _____ other _____ (specify)
14. Do you use a computer when dealing with accident investigations at the present time?
- Yes No
15. Do you currently use a personal computer at an accident site?
- Yes No

16. _____ would be my concern(s) in using a personal computer at an accident site. (circle all that apply).
- a. weight
 - b. size
 - c. shape
 - d. protection from environmental elements
 - e. difficulty of data input
 - f. risk of damage
 - g. loss of memory
 - h. other _____ (specify)
17. What area of application do you think a computer would be most beneficial in accident investigation? (circle one)
- a. information retrieval
 - b. data collection
 - c. data analysis
 - d. report form completion
 - e. other _____ (specify)
18. Do you have access to a personal computer in your office?
- Yes No
19. If you answered yes to #18, how often do you use the computer in the office?
- a. several times per day
 - b. at least once a day
 - c. at least once a week
 - d. less than once a week
20. Specialization:
- a. GA Operations
 - b. AC Operations
 - c. GA Airworthiness
 - d. AC Airworthiness
 - e. Avionics
 - f. Accident Prevention Program Manager
 - g. Other _____ (specify)
21. What FAA Region do you work in?
- a. Alaskan
 - b. Northwest Mountain
 - c. Western-Pacific
 - d. Southwest
 - e. Central
 - f. Great Lakes
 - g. New England
 - h. Eastern
 - i. Southern

22. Gender:

- a. Female
- b. Male

23. Your age:

- a. under 30
- b. 30-39
- c. 40-49
- d. 50 or more

24. Highest degree:

- a. high school degree
- b. associate's degree
- c. bachelor's degree
- d. master's degree
- e. doctorate degree

25. Have you received any formal computer instruction?

Yes No

26. Did you use a personal computer in your previous job?

Yes No

27. Do you use a personal computer at home?

Yes No

Additional comments: _____

APPENDIX B
SURVEY QUESTIONNAIRE COVER LETTER



U.S. Department
of Transportation
**Research and
Special Programs
Administration**

Transportation Safety Institute

P. O. Box 25082
Oklahoma City, Oklahoma 73125-5050

73

August 16, 1991

Frank T. Campana
FAA Chicago FSDO
9950 W. Lawrence Ave., #400
Schiller Park, IL 60176

Dear Frank,

We here at TSI are currently in the process of updating and revising the materials for our aircraft accident investigation courses. The revised text material will be called the *FAA's Desk Reference Guide to Aircraft Accident Investigation*. To augment the *Desk Reference Guide*, a *Field Investigator's Guide* is being created for use as a checklist at the accident site. Both the *FAA's Desk Reference Guide* and *Field Investigator's Guide* will be sent to you upon completion.

One of the chapters of the new *Desk Reference Guide* will review some of the research currently taking place regarding the computerization of some of the areas of aircraft accident investigation. Given the complexity of accident investigation, this area is of keen interest to TSI and the FAA. A research team at Embry-Riddle Aeronautical University is currently under contract to TSI to study computerized aircraft accident investigation methods. One of the steps in their research is to query active FAA Aviation Safety Inspectors to find out their opinions on the acceptance of the use of a computer as a tool in the investigation and reporting of accidents.

You have been selected to participate in this study to help us determine the possible benefits of using a personal computer in aircraft accident investigation. To carry out this task, the enclosed survey questionnaire has been developed to collect your opinions of using a computer to perform various roles during the investigation process. Please complete the enclosed questionnaire and return it in the self-addressed stamped envelope by September 1, 1991. Your responses will be anonymous and no attempt will be made to identify any response with any specific inspector. To control this study, a number has been assigned to the enclosed questionnaire. If you wish total anonymity and confidentiality, feel free to cut the control number off.

We appreciate your cooperation and support in this effort. Without your help, we will not be able to complete this study to shed some light on automating aviation accident investigation. If you have any further questions concerning this project, please feel free to contact us at (405) 680-3614

Sincerely,

Burton P. Chesterfield, P.E.
Manager, Aviation Safety Division
Transportation Safety Institute

David S. Ryan
Graduate Research Assistant
Embry-Riddle Aeronautical University

APPENDIX C
RESPONSES TO OPINION QUESTIONS (1-10)

Responses to Likert Scale Questions (1-10)

| Survey Question | Total Responses per Answer (Percentage per Cell) | | | | | | | | | |
|--------------------|---|--------|-------|--------|-----------|--------|----------|--------|----------------------|-------|
| | Strongly Disagree | | Agree | | Undecided | | Disagree | | Strongly Disagree | |
| | N | % | N | % | N | % | N | % | N | % |
| 1 | 40 | (33.1) | 46 | (38.0) | 16 | (13.2) | 14 | (11.6) | 5 | (4.1) |
| 2 | 34 | (28.1) | 45 | (37.5) | 24 | (20.0) | 12 | (10.0) | 5 | (4.2) |
| 3 | 22 | (18.3) | 58 | (48.3) | 24 | (20.0) | 13 | (10.8) | 3 | (2.5) |
| 4 | 50 | (41.3) | 51 | (42.1) | 11 | (9.1) | 7 | (5.8) | 2 | (1.7) |
| 5 | 51 | (42.1) | 48 | (39.7) | 11 | (9.1) | 9 | (7.4) | 2 | (1.7) |
| 6 | 47 | (38.8) | 45 | (37.2) | 21 | (17.4) | 5 | (4.1) | 3 | (2.5) |
| 7 | 24 | (20.0) | 41 | (34.2) | 30 | (25.0) | 17 | (14.2) | 8 | (6.7) |
| 8 | 44 | (36.4) | 48 | (39.7) | 15 | (12.4) | 9 | (7.4) | 5 | (4.1) |
| 9 | 26 | (21.5) | 61 | (50.4) | 25 | (20.7) | 6 | (5.0) | 3 | (2.5) |
| 10 | 42 | (34.7) | 50 | (41.3) | 19 | (15.7) | 6 | (5.0) | 4 | (3.3) |